Radiation Detection Equipment

An Arms Control Verification Tool

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This special interest pamphlet was prepared by the Defense Treaty Inspection Readiness Program (DTIRP) to increase ***Readiness Through Awareness*** at Department of Defense (DoD) and defense contractor facilities. The pamphlet is intended to assist treaty compliance officers, security personnel, and others responsible for implementing arms control treaties focused on reducing the number of nuclear weapons.

Additional copies of this pamphlet and other educational materials on arms control security and treaty-implementation topics are available from the DTIRP Website and by contacting the DTIRP Outreach Program Coordinator.

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INTRODUCTION

Experience has shown that the use of radiation detection equipment (RDE) provides treaty partners with a high degree of confidence in the inspection team's ability to verify treaty compliance. It has also shown that the rigorous procedures established for using RDE allow national escorts and site personnel to ensure facility safety and security. When these procedures are combined with managed access techniques and appropriate security countermeasures, treaty implementers are effectively able to both demonstrate compliance while also protecting national security, proprietary, and other critical information.

This pamphlet summarizes the procedures required for using RDE during on-site inspection activities and the procedures for approving RDE for use in the United States. The pamphlet begins by describing the use of RDE introduced under the Intermediate-Range Nuclear Forces (INF) Treaty and compares this successful experience with the use of RDE under the Strategic Arms Reduction Treaty (START). This discussion includes a review of the steps taken to ensure the safety and security of facility personnel. The pamphlet ends with a brief look at possible uses of RDE in the future.

WHAT IS RDE?

Radiation detection equipment, as defined in the context of this pamphlet, is equipment that is designed to detect the presence or confirm the absence of radioactive materials. RDE accomplishes this task by counting the neutrons emitted from decaying radioactive materials—specifically uranium and plutonium. The U.S. RDE set was designed by Sandia National Laboratories and consists of a specially designed neutron detector and commercial off-the-shelf components. It is "simple" in the sense that it is designed to accomplish one specific purpose—to count neutrons—and requires little maintenance.

Radiation Detection Equipment set

The specially designed neutron detector is composed of 12 commercially available, proportional counter tubes embedded in a polyethylene block. The block is encased in a thin cadmium sheet and is enclosed in an aluminum box (30 cm x 25 cm x 6.5 cm).

Each counter tube is an aluminum cylinder (25 cm long x 2.5 cm in diameter) that is pressurized to ten atmospheres with helium^3 gas. Inside each tube is an electrically charged wire that detects the electrical pulses caused by the neutrons when they react with the helium gas.

The electrical pulses are amplified to drive the signal through 15 meters of cable to a commercially available Eberline ESP-2 counting unit. The counting unit is powered by six regular C-cell batteries, which supply power to the detector.

In addition to the neutron detector, cable and counting unit, the U.S. RDE set includes a tripod to mount the detector and a radioactive calibration source. It also includes miscellaneous equipment such as a Hewlett-Packard HP-27S programmable calculator and a 4 x 4 meter coordinate grid.

Each set of RDE carried by an inspection team includes two detectors, two cables and two counting units to provide redundancy. It also includes a tripod. The equipment is stored and transported in four aluminum suitcases.

RDE UNDER THE INF TREATY

RDE was originally developed for the use of U.S. inspectors during on-site inspection activities conducted to verify compliance with the INF Treaty. Specifically, this equipment was developed to help U.S. inspectors verify the elimination of Soviet SS-20 missiles at converted missile bases.

SS-20 missile on mobile launcher

The INF Treaty required all SS-20 missiles and their operating bases to be eliminated. However, the Soviet Union indicated during treaty negotiations that it intended to convert some SS-20 operating bases to SS-25 inter-continental ballistic missile (ICBM) bases instead of eliminating them. The challenge for the United States was to verify that no SS-20 missiles remained at the converted bases.

This verification challenge was enhanced because the canisters used for SS-25 ICBMs were large enough to contain an SS-20 missile and both types of missiles utilized a sealed launch canister mounted on a mobile launcher. A significant difference was that SS-25 ICBM's contained a single warhead whereas SS-20 missiles were capable of carrying three warheads.

Initially the United States argued that U.S. inspectors should be allowed to view inside an SS-25 launch canister to confirm that an SS-20 missile was not present. The Soviet Union was firmly opposed to this approach. After further extensive negotiations, the Soviet Union agreed to a U.S. proposal

giving U.S. inspectors the right to use RDE to measure the neutron flux (the number of neutrons per square centimeter) emanating from a launch canister.

A launch canister with a missile containing a single warhead (SS-25) would emit a different number and pattern of neutrons than a launch canister containing a missile with three warheads (SS-20). A U.S. inspection team using RDE to examine a canister declared to contain an SS-25 missile could compare its measurements against a set of benchmark radiation measurements to confirm that the canister did not contain an SS-20.

Benchmark Measures

In July 1989, the United States conducted a number of special inspections on SS-20 and SS-25 missiles to establish benchmark neutron flux measurements. U.S. inspectors transported three sets of RDE to Moscow. As agreed in previous negotiations, the Soviet Union selected one of the RDE sets to purchase. The United States stored one set in Moscow and transported one set to the inspection site where it was used to take the benchmark measurements.

Approximately 100 measurements were taken on each of two randomly selected mobile launchers containing an SS-20 missile and two randomly selected mobile launchers containing an SS-25 missile. Over 80 measurements were taken on a 4 x 4 meter horizontal plane, a ½-meter below each launch canister.

Measurements were also taken at ½-meter intervals along the top of the launch canister and along a vertical line to the left front side of the launch canister, no closer than ½-meter from the canister. This RDE benchmark measurement data was confirmed on site by the Soviet escorts and became the standard against which all subsequent radiation measurements were compared.

INF Treaty Operations

Under the INF Treaty, it was only the United States that used RDE during on-site inspection activities. In the Soviet Union and its successor states, the U.S. inspection teams followed all regulations required to assure the safety and security of a low-level radioactive calibration source (americiumlithium^{241}), including its secure storage and transport.

The United States used RDE to determine whether there were indications that an SS-20 missile system was present at former SS-20 missile operating bases that had been converted for a missile system "not subject to the Treaty" (the SS-25). During on-site inspection activities at these converted operating missile bases, radiation measurements were taken at up to ten points in the 4 x 4-meter horizontal plane and up to four points along the top of the canister for each of the nine SS-25 ICBMs at the base (see Image 1).

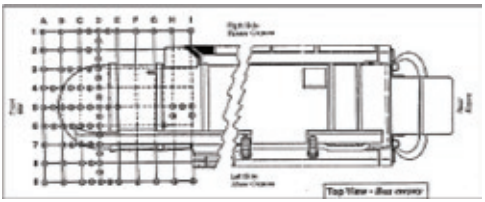

Image 1: **Grid positions for horizontal measurements**

With experience, U.S. inspectors and Russian escorts were able to reduce the amount of time required to complete all 14 measurements on an SS-25 from more than three hours to about 1½ hours. Russian escorts participated in the radiation measurement process by positioning the detector at the locations specified by the U.S. inspection team and by calculating and recording the neutron flux data at each measurement point.

After completing each measurement at a specified point, the two parties compared the results with the RDE benchmark measurement for that point on an SS-25 ICBM. After all 14 measurements were completed, the missile was considered to be a missile "not subject to the Treaty" if none of the data differed by more than 50 percent from the respective benchmark data.

If the data for any point "busted flux" (differed by more than 50 percent), Russian escorts were required to open the launch canister and to allow U.S. inspectors to visually confirm that the missile was not an SS-20.

After the radiation measurements for all nine launch canisters were completed, the U.S. inspectors also had the right to randomly select one launch canister and to have it opened by the Russian escorts for visual inspection. This provision was added to increase confidence in the inspection process and could be *requested* regardless of the outcome of the RDE measurements.

Between 1989 and June 1996, the United States used RDE to help verify compliance with the INF Treaty during 27 inspections. No SS-20 missiles were found. In addition to the randomly selected SS-25 launch canisters opened during each inspection, four canisters were opened at two SS-25 missile bases due to "busting flux." It was found that the reason these radiation measurements differed from the benchmark by more than 50 percent was because there were no warheads on those SS-25 ICBMs.

Beginning in July 1996, U.S. inspectors no longer encountered SS-25 launchers or ICBMs at SS-25 bases converted from former SS-20 operating bases. The mobile launchers were routinely on field exercises. Although U.S. inspection teams were prepared to use RDE from 1996 until inspections ended under the INF Treaty on June 1, 2001, there was never again an opportunity to use RDE under the INF Treaty.

STRATEGIC ARMS REDUCTION TREATY

When the Strategic Arms Reduction Treaty (START) was negotiated, provisions were included to allow limited use of RDE. Under the START Treaty, RDE could be used to detect the presence of nuclear material in the following two situations:

- to confirm the absence of long-range nuclear air-launched cruise missiles (LRNA's) during an inspection of a weapons storage area at an airbase used for heavy bombers not equipped for LRNA's; and
- during a reentry vehicle (RV) inspection (RVOSI), to determine whether an object in the front section of an ICBM or submarine-launched ballistic missile (SLBM) declared to be non-nuclear, was, in fact, non-nuclear.

Although the START Treaty entered into force on December 4, 1994, the procedures for RDE use were not agreed until September 1995. The delay was due in part to a difference of opinion about the type of RDE to be used. The United States preferred to use a different type of RDE rather than the type of RDE used under the INF Treaty.

Russia had developed a set of RDE based on the RDE purchased by the Soviet Union in 1989. As a result, it appeared the Russians did not want to allow U.S. inspectors to use a new type of RDE that could be very different from their own. A new set of RDE would require new procedures for use and could create additional security concerns for the Russians.

Realizing that the Russians were familiar with the RDE used under the INF Treaty and had confidence in its capabilities for detecting only the presence of radiation, and nothing more, the United States agreed to use the same set of RDE used under the INF Treaty for START inspections. Unlike the INF Treaty though, no benchmark measurements were taken.

Under the START Treaty, Russian inspectors had the right to use RDE in the United States. Fortunately, since the Russian RDE set was developed from an American RDE system, the Russian RDE set was able to use the same calibration source.

The On-Site Inspection Agency (OSIA, forerunner of the Defense Threat Reduction Agency's (DTRA) On-site Inspection Directorate) developed procedures for using the Russian RDE in the United States and trained U.S. escorts to transport the low-level radioactive calibration source to the inspection site and to store it securely while the inspection team was at the site. These procedures were in accordance with Nuclear Regulatory Commission (NRC) and Department of Defense (DoD) regulations.

Before it could be used in the United States, the Russian RDE was examined by U.S. Technical Equipment Inspection (TEI) personnel in the presence of Russian inspectors. During this operations test, the RDE was partially disassembled, examined, photographed, reassembled and tested to ensure that it operated properly and could not perform functions unrelated to the Treaty.

Russian RDE undergoing operations test

Current START Procedures

Under the START Treaty, if an inspection team at a weapons storage area discovers an object large enough to be, or to contain, a LRNA, the team has the right to designate no more than three such objects for further inspection. To determine whether the object contains a radiation source, a background radiation measurement is taken at a location at least ten meters away from any radioactive source. This background measurement is used later to calculate a comparison number.

The object being inspected is moved to an area at least ten meters away from any other object and the inspection team designates four points along

the length of the object. These points are recorded on a diagram of the object and are included in the inspection report. The escorts position the RDE at the locations designated by the inspection team, at a distance of between seven centimeters and two meters away from the surface of the object. This range is required to accommodate the different sensitivities of the U.S. and the Russian sets of RDE.

The measurements at each of the four points are compared to the comparison (background) number. If the measurement at each of the four points is less than or equal to the comparison number, the object is not subject to further inspection. However, if the measurement at any of the four points is greater than the comparison number, the object is subject to further inspection. These inspection activities may include taking linear measurements, taking additional radiation measurements, and taking photographs.

While conducting an RVOSI, an inspection team may not be convinced that an object in the front section of an ICBM or SLBM is not an RV, even though the escorts have declared that it is not an RV. In this situation, the escorts may choose to use the inspection team's RDE to determine whether or not the object contains nuclear material. The implied conclusion is that if the object does not contain nuclear material, then it is not an RV. There are three methods for taking this radiation measurement:

- remove the object in question to a point at least ten meters away from the front section of the ICBM or SLBM, and take the radiation measurement;
- remove all RVs to a distance at least ten meters away from the front section of the ICBM or SLBM containing the object in question, leave the object in place, and take the radiation measurement; or
- leave all items in place, shield the object in question from the radiation of the RVs, and take the radiation measurement.

Once the escort has decided to use RDE, a comparison number is calculated as described earlier. After the object in question has been isolated from the RVs by one of the three methods described above, the escort positions the neutron detector at a location specified by the

inspection team—again between seven centimeters and two meters away from the surface of the object.

The inspection team is permitted to prepare a diagram of the object and to have this diagram included in the inspection report. The diagram may indicate the object's approximate dimensions (estimated without making linear measurements), shape, and the location where the radiation measurement was taken.

The radiation measurement is compared with the comparison number. If the measurement is less than or equal to the comparison number, the object is considered to be non-nuclear. If the radiation measurement is greater than the comparison number, that fact is recorded in the inspection report.

History of RDE Use

Russia and the United States have had RDE sets in place since 1995. However, RDE use has been limited. From 1998 through 2006, RDE has only been used during eight RV inspections. All of these inspections were conducted by U.S. inspectors in Russia—once in 1998, twice in 1999, and once in 2002, 2003, 2004, 2005 and 2006.

It is important to note that RDE has been effective within the parameters set for its use. Until recently, radiation measurements had been inconclusive in resolving some non-nuclear issues arising during on-site inspection activities. Following extensive discussions in March 2002 in the Joint Compliance and Inspection Commission (JCIC)—the START Treaty's implementation organization—Russian escorts again elected to use the inspection team's RDE to confirm that an object in the front section of an SS-18 ICBM was non-nuclear. This occurred during an RVOSI in April 2002.

The results in this case were acceptable to the United States and a long-standing issue was successfully resolved. In accordance with Annex 8 of the Inspection Protocol as revised by JCIC Agreement 54 and in accordance with the procedures for RDE use, testing, and storage outlined in Annex 15 to the START Treaty Inspection Protocol, Russia inserted new sets of RDE into both of the points of entry (POE) in the United States in 2005.

FUTURE POSSIBILITIES

Since on-site inspection activities under the INF Treaty ended on June 1, 2001, the use of RDE under the INF Treaty has also ended. RDE is likely to continue to be used sparingly under the START Treaty and only by the United States when conducting inspection activities in Russia.

It is possible that RDE could be used under future arms control treaties and agreements. Past experience with RDE use has shown that treaty partners have confidence in RDE's capabilities for providing necessary data quickly and with a minimum of interference or intrusion.

CONCLUSION

One of the most significant challenges associated with hosting on-site inspection activities is limiting the inspection team's ability to collect sensitive information. Approved RDE systems are designed to provide only the minimum amount of information needed to allow an inspection team to confidently count and confirm the number of warheads present.

TEI personnel help to protect facility safety and security by conducting a full examination of RDE before it is approved for use at U.S. facilities. In addition, escorts and facility staff employ treaty-compliant and cost-effective security countermeasures to reduce the risk of inadvertently disclosing sensitive information. These protective measures may include shrouding, limiting the inspectors' access to areas and information, and carefully planning inspection routes.

To request assistance or to obtain more information about arms control security and treaty implementation, contact the DTIRP Outreach Program Coordinator at 1-800-419-2899, or send an email to dtirpoutreach@dtra.mil. You may also contact your local Defense Security Service (DSS) Industrial Security Representative or your government sponsor.

Additional information and materials can be downloaded directly from the DTIRP website at: http://dtirp.dtra.mil.

LIST OF ABBREVIATIONS

DoD	Department of Defense
DSS	Defense Security Service
DTIRP	Defense Treaty Inspection Readiness Program
DTRA	Defense Threat Reduction Agency
INF	Intermediate-Range Nuclear Forces Treaty
JCIC	Joint Compliance and Inspection Commission
NATO	North Atlantic Treaty Organization
NRC	Nuclear Regulatory Commission
NTM	National technical means
OSIA	On-Site Inspection Agency (now the On-Site Inspection Directorate at DTRA)
POE	Point of entry/exit
RDE	Radiation detection equipment
START	Strategic Arms Reduction Treaty
TEI	Technical equipment inspection

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